THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 98:33–40, 1995 May

THE FIRST CALTECH–JODRELL BANK VLBI SURVEY. II. λ = 18 CENTIMETER OBSERVATIONS OF 25 SOURCES

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Received 1993 December 30; accepted 1994 November 2

ABSTRACT

We report λ-18 cm VLBI observations made in 1991 September of a further 25 objects from the first Caltech–Jodrell Bank VLBI Survey (the CJ1 survey). The CJ1 sample is a complete, flux-density limited sample of 135 radio sources with total flux density at λ-6 cm between 0.7 and 1.3 Jy. These observations complete the λ-18 cm part of the survey. Together with the results of Paper I (Polatidis et al.), we have now observed 81 CJ1 sources at λ-18 cm. Later papers in the series will present λ-6 cm observations and the analysis and interpretation of the results.

Subject headings: quasars: general — radio continuum: galaxies — surveys — techniques: interferometric

1. INTRODUCTION

In this paper we present λ-18 cm VLBI observations of a further 25 sources from the first Caltech–Jodrell Bank VLBI Survey (hereafter the CJ1 survey). These observations complete the λ-18 cm part of the survey. The scientific objectives of the survey and the selection of the sample were described in Paper I (Polatidis et al. 1995). The CJ1 sample consists of all the sources in the NRAO-MPIfR S4 and S5 surveys (Pauliny-Toth et al. 1978; Kühr et al. 1981) which satisfy the following criteria: declination (1950.0) $\delta > 35°$; Galactic latitude $|b| > 10°$; total λ-6 cm flux density 1.3 Jy $> S_{6\,\mathrm{cm}} >$ 0.7 Jy.

There are 135 sources in this sample of which 92 are observable with the Mark II VLBI system. The other 43 objects have weak compact central components with flux density of less than 0.2 Jy. Most of these sources have been optically identified and redshifts have been measured. We have mapped 81 of the sources at λ-18 cm (Paper I and this paper) and 87 at λ-6 cm (Xu et al. 1995). A list of all the sources in the complete sample, together with their redshifts, optical identifications, and total radio flux densities was given in Paper I.

2. OBSERVATIONS

The 25 sources presented in this paper were observed in one contiguous global VLBI network run of 48 hr in 1991 September. The participating telescopes are listed in Table 1, with their system temperatures and sensitivities.[1] The data were recorded using the NRAO Mark II system with an effective bandwidth of 1.8 MHz centered at 1.665 GHz in left circular polarization (LCP). Hydrogen masers were used as time and frequency standards at each telescope.

[1] The VLBA, the VLA, and the 140 foot (43 m) Green Bank telescope are instruments of the National Radio Astronomy Observatory, which is operated by Associated Universities, Inc., under cooperative agreement with the National Science Foundation.

To use the network time efficiently, we used the "snapshot" technique. Instead of using a few antennas and a long track, this technique uses a large number of antennas (13 for this observation). Each source was observed in three or four scans of 30 minutes each, as described in Paper I. The map quality is limited by thermal noise rather than the loss of u, v coverage resulting from the use of the snapshot technique. The images of most of the sources in the sample have dynamic range greater than 100:1.

The correlation of the data was carried out at Caltech using the JPL–Caltech Block II correlator. The 16 station correlator allowed us to correlate the data for all the telescopes in a single pass. This eliminates nonclosing errors caused by errors in tape reading. The sources 0552+398 and 1739+522 were used as fringe finders. The fringe fitting was done using the AIPS task FRING, and calibration, editing, and mapping were done using the Caltech VLBI package and DIFMAP, as described in Paper I.

3. RESULTS

The source list and map parameters are given in Table 2, and the maps are shown in Figure 1. As in Paper I, for each source we present a "naturally weighted" maps with a resolution of ~3 mas (FWHM), and a "tapered" map with a resolution of ~10 mas. We could not obtain a reliable image for the source 0827+378, since it is completely resolved on baselines longer than 15 Mλ. From the visibility data, we can put an upper limit of 75 mJy on the core flux density.

We attempted to model the brightness distribution of each source with simple elliptical Gaussian components, using the least-squares model-fitting algorithm in DIFMAP. The model components are listed in Table 3. We do not list models for four sources for which we could not obtain agreement factors of less than 1.5 with fewer than five components.

TABLE 1

TELESCOPE CHARACTERISTICS

Telescope	Code	Location	Diam (m)	T_{sys} (K)	T_{sys} (Jy)	Sensitivity (K/Jy)
Effelsberg	B	Germany	100	—	28	—[a]
WSRT	W	Netherlands	5×25	—	168	—[a]
Lovell	J	Jodrell Bank, UK	76	47	56	0.8
NRAO	G	Green Bank, WV, USA	43	21	72	0.3
Haystack	K	Westford, MA, USA	36	172	1066	0.16
VLBA_PT	PT	Pie Town, NM, USA	25	34	340	0.1
VLBA_KP	KP	Kitt Peak, AZ, USA	25	35	350	0.1
VLBA_LA	LA	Los Alamos NM, USA	25	33	330	0.1
VLBA_NL	NL	North Liberty, IA, USA	25	35	350	0.1
VLBA_FD	FD	Fort Davis, TX, USA	25	34	340	0.1
VLBA_BR	BR	Brewster, WA, USA	25	29	291	0.1
VLA[b]	Y	Socorro, NM, USA	25	45	450	0.1
OVRO	O	Owens Valley, CA, USA	40	53	254	0.21

[a] T_{sys} measurements supplied in janskys.

[b] The VLA was used in single antenna mode.

NOTES.—Cols. (1)–(3): the name, the code used and the location of each telescope. Col. (4): the diameter of each telescope (in meters). Cols. (5)–(7): The system temperature in kelvins and in janskys and the sensitivity in kelvins per jansky of each telescope.

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TABLE 2

MAP PARAMETERS

Name	Naturally Weighted Maps: Beam[a] a (mas)	b (mas)	θ (°)	S_{peak} (mJy/beam)	rms (mJy/beam)	Tapered Maps: Beam[a] a (mas)	b (mas)	θ (°)	S_{peak} (mJy/beam)	rms (mJy/beam)
0022+390...	7.88	2.72	−18	521	0.49	15.18	8.00	−7	601	1.01
0646+600...	4.98	3.02	32	580	0.35	11.56	9.46	72	670	0.52
0650+371...	7.76	2.71	−15	963	0.46	15.23	8.59	−7	1030	0.76
0707+476...	7.76	2.64	0	859	0.44	16.46	8.69	17	956	0.74
0820+560...	5.13	3.40	−76	755	0.43	12.28	8.81	−44	862	0.64
0821+394...	7.52	2.58	−11	216	0.73	14.90	8.30	−3	311	1.87
0917+624...	4.08	3.15	−17	751	0.57	11.08	9.51	−22	1010	0.68
1003+830...	3.83	2.91	−73	192	0.36	12.67	10.09	−39	394	0.66
1015+359...	11.05	2.53	−17	561	0.39	19.48	8.30	−8	632	0.53
1044+719...	3.62	3.03	−71	900	0.35	13.70	11.54	−29	970	0.63
1053+704...	3.56	3.37	−54	607	0.38	12.23	9.94	−41	669	0.75
1053+815...	3.54	3.12	−26	594	0.33	13.06	12.67	5	635	0.65
1058+726...	4.21	3.17	−89	476	0.33	11.38	9.34	−31	665	0.92
1144+402...	9.04	2.65	−10	334	0.29	16.23	8.68	1	391	0.48
1311+678...	3.85	2.92	−38	161	0.62	10.65	8.75	−20	519	1.10
1333+589...	3.93	3.12	3	207	0.26	11.48	10.76	−14	293	0.49
1342+663...	4.39	2.76	−11	662	0.32	12.52	9.76	−2	784	0.72
1357+769...	3.53	3.26	−65	583	0.29	12.07	10.32	−60	639	0.52
1437+624...	3.98	2.92	4	323	0.59	12.39	10.21	50	1000	0.94
1547+507...	4.42	3.09	−27	298	0.51	10.66	9.18	−15	655	0.80
1656+477...	5.46	2.64	−13	805	0.32	15.46	11.19	3	1030	0.68
1656+482...	5.52	2.93	−8	459	0.26	13.12	9.64	−1	563	0.51
1734+508...	4.31	3.10	−33	415	0.30	11.31	10.02	−36	575	0.70
2207+374...	8.91	2.59	−19	333	0.37	15.04	7.57	−8	635	0.77

[a] The restoring beam is an elliptical Gaussian with FWHM major axis a and minor axis b, with major axis at position angle θ.

NOTES.—Col. (1): source name. Cols. (2), (3), and (4): the beam characteristics of the naturally weighted maps. Col. (5): the peak flux density of the naturally weighted maps (mJy beam^{-1}). Col. (6): the rms noise in the naturally weighted maps (mJy beam^{-1}). Cols. (7), (8), and (9): the beam characteristics of the tapered maps. Col. (10): the peak flux density of the tapered maps (mJy beam^{-1}). Col. (11): the rms noise in the tapered maps (mJy beam^{-1}).

Table 2 is published in computer-readable form in the AAS CD-ROM Series, Vol. 4.

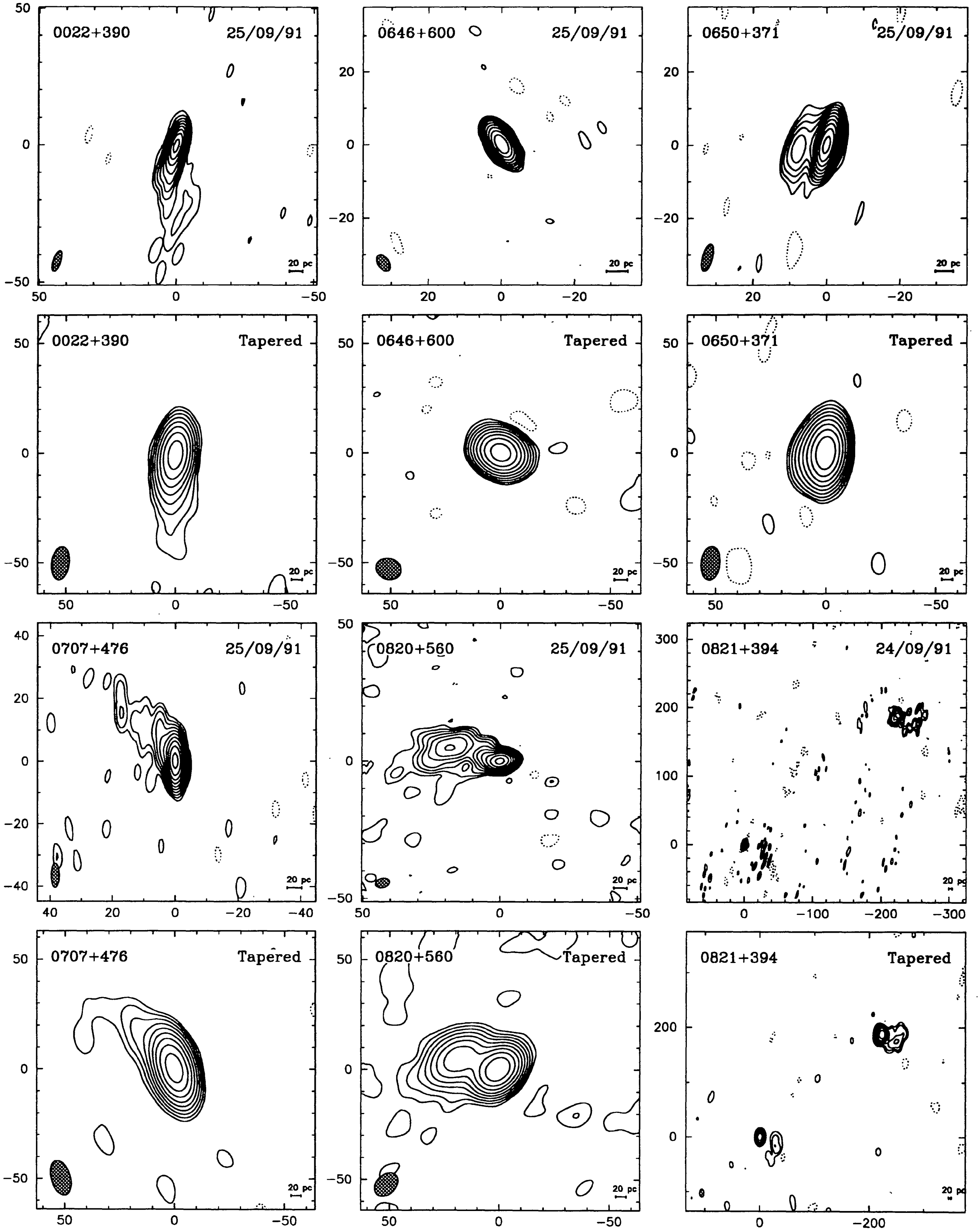

FIG. 1.—The λ-18 cm VLBI maps of 24 sources. For each source the top panel shows the naturally weighted, higher resolution map, and the bottom panel shows the tapered map. Logarithmic contour levels are used in all maps, drawn at −2, −1, 1, 2, 4, 8, 16, ⋯ 1024 × 3 σ (where σ is the rms noise measured in an empty region of the map). The FWHM contour of the elliptical Gaussian restoring beam is shown hatched in the lower left-hand corner. The peak flux density, rms noise and parameters of the restoring beam are given in Table 2. The angular scale is marked in milliarcsec and, where the source redshift is known, the linear scale of each map is indicated in the lower right-hand corner (assuming H_0 = 100 km s^{-1} Mpc^{-1} and q_0 = 0.5). Note that the field of view of the tapered map is usually larger than that of the uniformly weighted map.

FITS images corresponding to the maps presented in Fig. 1 are published in the AAS CD-ROM Series, Vol. 4.

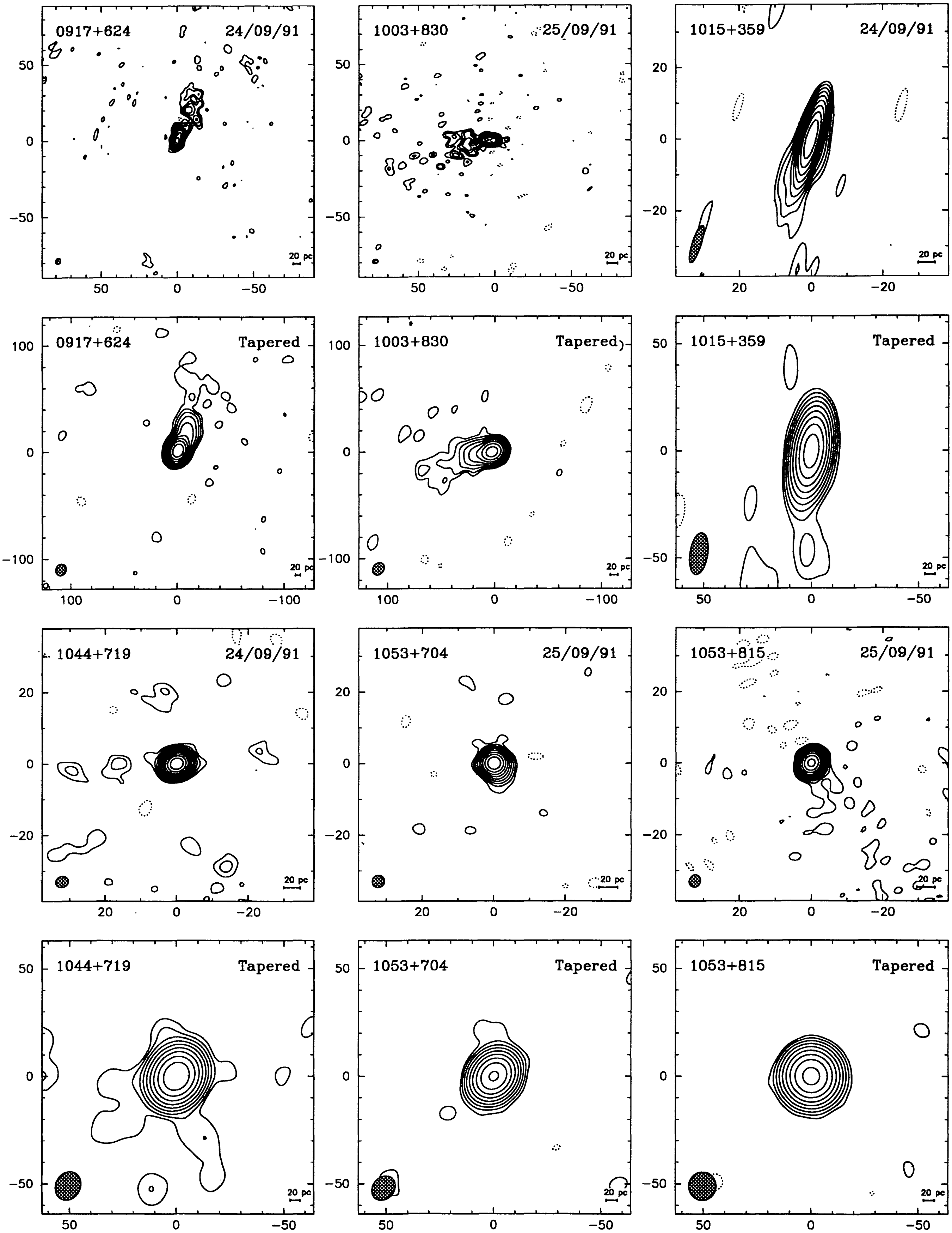

FIG. 1.—*Continued*

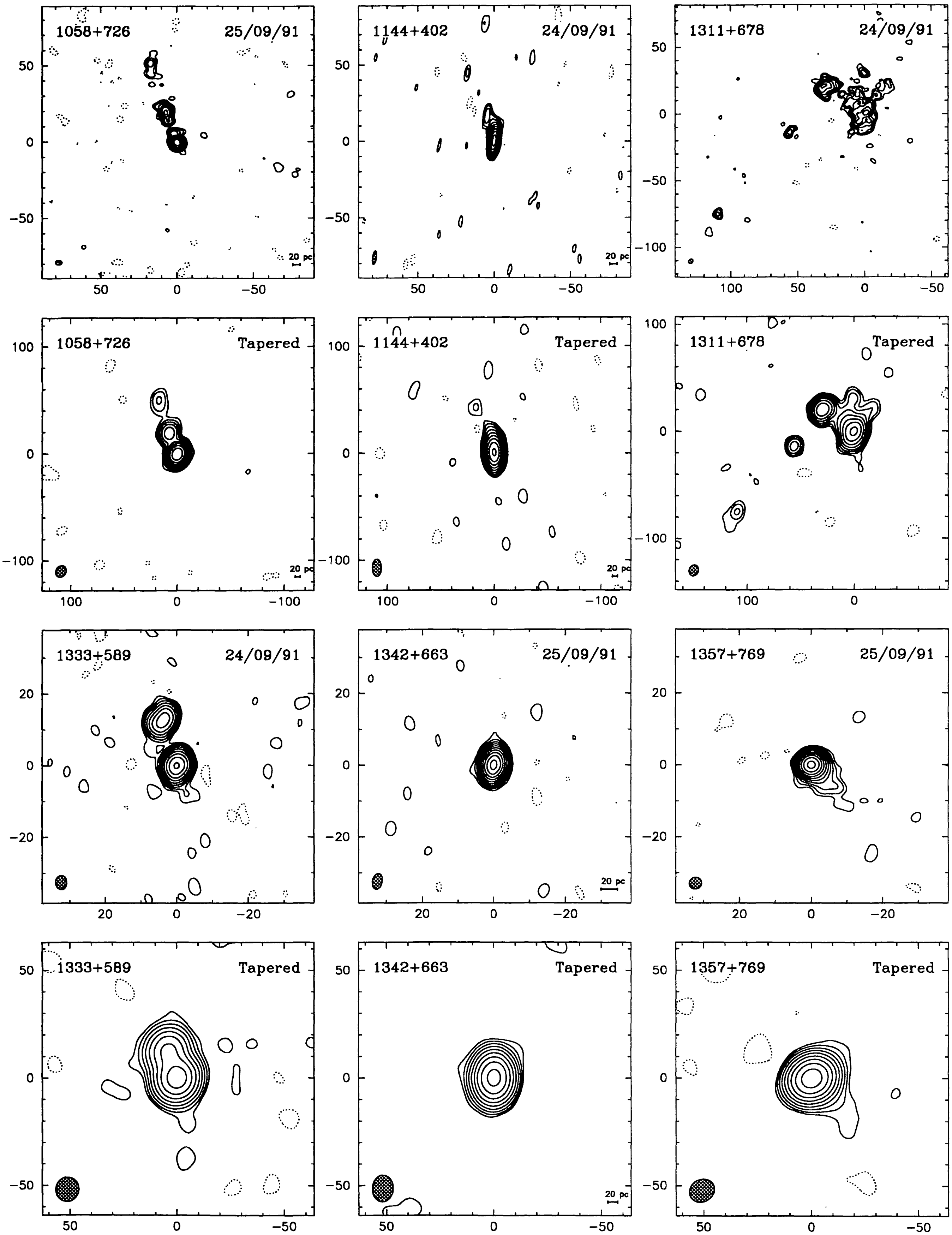

FIG. 1.—*Continued*

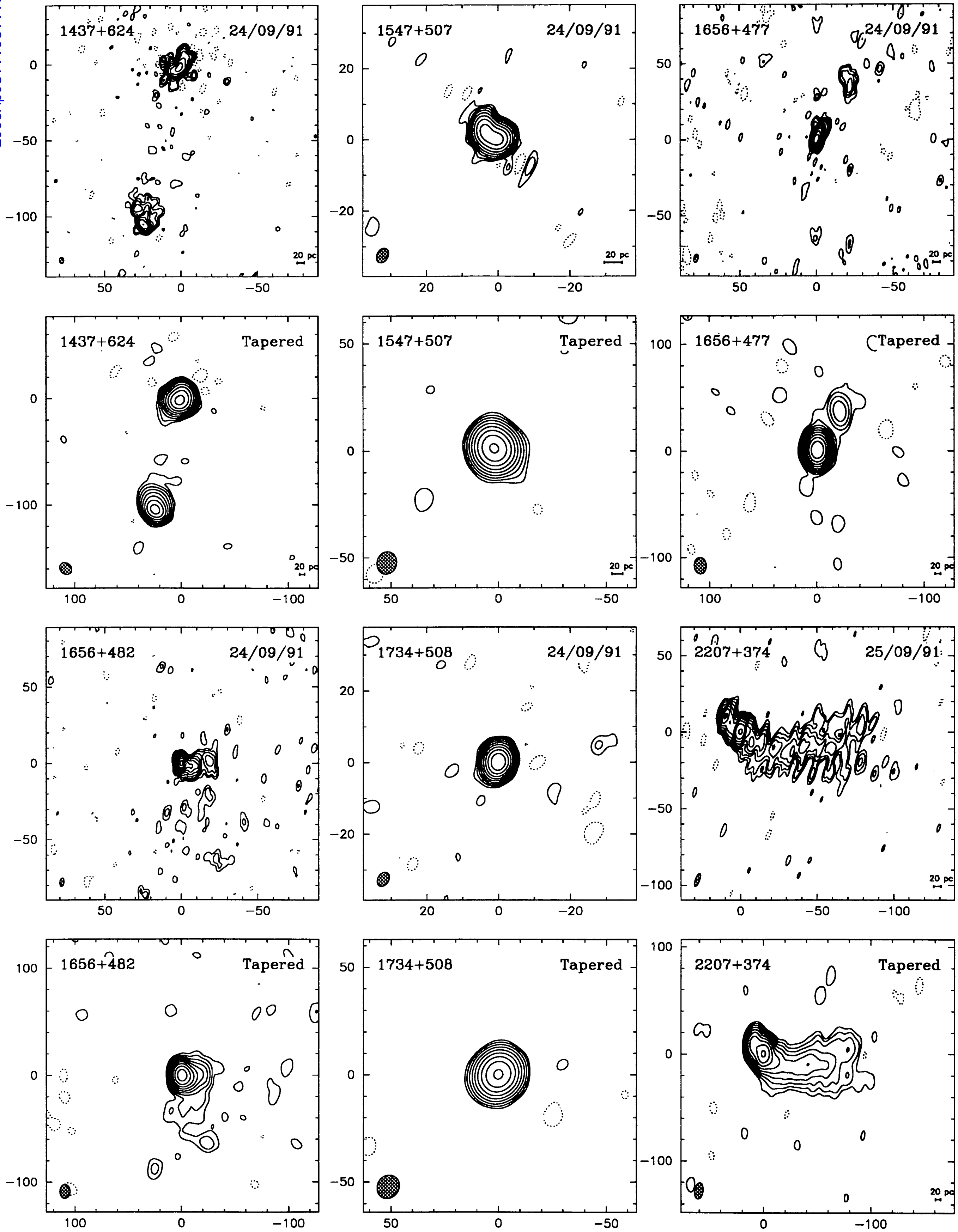

FIG. 1.—*Continued*

TABLE 3

GAUSSIAN MODELS

Source	S (Jy)	r (mas)	θ (°)	a (mas)	b/a	Φ (°)	χ^2
0022+390...	0.504	0.00	0.0	1.30	0.00	17.2	1.086
	0.185	6.49	168.6	11.22	0.28	−10.3	
0646+600...	0.700	0.00	0.0	3.23	0.18	32.3	1.279
0650+371...	1.011	0.00	0.0	1.26	0.69	6.4	0.931
	0.088	6.91	95.5	7.38	0.44	−51.7	
0707+476...	0.930	0.00	0.0	1.34	0.50	44.0	1.130
	0.089	10.69	34.3	9.13	0.00	−38.2	
0820+560...	0.728	0.00	0.0	1.98	0.00	86.7	1.282
	0.234	3.72	75.7	5.45	0.27	65.6	
	0.266	18.16	72.7	8.59	0.59	−81.8	
	0.059	23.73	83.7	7.39	0.45	30.6	
0917+624...	0.775	0.00	0.0	1.28	0.53	−9.7	1.269
	0.378	4.95	−20.3	2.44	0.82	26.8	
	0.159	20.73	−24.8	21.12	0.44	−7.5	
1003+830...	0.251	0.00	0.0	2.01	0.84	62.6	1.282
	0.217	5.15	85.3	2.20	0.83	72.5	
	0.103	18.97	98.0	14.67	0.67	−47.5	
1015+359...	0.596	0.00	0.0	2.73	0.25	−1.3	0.844
	0.068	6.97	169.2	10.84	0.22	−22.7	
1044+719...	0.975	0.00	0.0	1.04	0.88	−63.8	0.797
1053+704...	0.674	0.00	0.0	1.35	0.69	65.4	1.037
1053+815...	0.638	0.00	0.0	0.97	0.87	−71.4	0.767
1058+726...	0.681	0.00	0.0	3.04	0.32	15.1	1.290
	0.037	3.71	−146.0	13.06	0.00	−72.3	
	0.017	11.29	25.1	13.52	0.00	−56.1	
	0.068	20.44	21.4	5.00	0.26	−85.1	
	0.019	24.07	19.9	5.09	0.00	85.6	
	0.016	53.74	19.1	7.27	0.39	−45.3	
1144+402...	0.320	0.00	0.0	1.36	0.69	6.7	0.823
	0.087	3.60	1.0	3.20	0.57	70.2	
	0.012	17.29	15.5	3.38	0.18	−64.1	
1333+589...	0.301	0.00	0.0	2.86	0.61	−51.7	1.044
	0.126	13.31	16.0	4.58	0.27	−41.9	
1342+663...	0.798	0.00	0.0	1.72	0.71	−85.1	0.795
1357+769...	0.648	0.00	0.0	1.28	0.67	68.8	1.071
1547+507...	0.360	0.00	0.0	2.96	0.47	65.9	1.025
	0.430	4.22	58.2	4.02	0.11	28.7	
	0.009	11.27	−131.0	8.54	0.00	−20.1	
1656+477...	0.820	0.00	0.0	1.12	0.52	23.3	0.982
	0.301	5.04	−23.1	3.72	0.59	−17.3	
	0.047	42.09	−30.9	22.25	0.41	−22.8	
1656+482...	0.467	0.00	0.0	1.38	0.51	63.9	1.091
	0.240	6.22	−102.9	10.74	0.59	87.1	
1734+508...	0.631	0.00	0.0	2.99	0.59	27.7	0.999

NOTE.—Parameters of each Gaussian component of the model brightness distribution: S, flux density; r, θ, polar coordinates of the center of the component relative to an arbitrary origin, with polar angle measured from north through east; a, b, major and minor axes of the FWHM contour; Φ, position angle of the major axis measured from north through east. The sources 0821+394, 1311+678, 1437+624, and 2207+374 were too complicated to model.

Table 3 is published in computer-readable form in the AAS CD-ROM Series, Vol. 4.

We thank the staff at the observatories in the European and the US VLBI Networks, and AGP acknowledges the receipt of British Council Fellowship for the year 1991. The work at Caltech is supported by the National Science Foundation (grants AST-8814554 and AST-9117100). We are grateful to the referee, Margo Aller, for helpful comments.

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